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The use of 25 Sprotte needle markedly reduces post-dural puncture headache in routine neurological practice

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Abstract

Objectives: to test the feasibility of lumbar puncture (LP) using 25 gauge (G) needles in daily neurological practice and to compare the risk of post-dural puncture headache (PDPH) with 4 types of needles.

Methods: In a prospective rater-blind study, pros and cons of 4 different LP needles, 20G Quincke (20Q), 22G Sprotte (22S), 25G Whitacre (25W), and 25G Sprotte (25S), were evaluated in 394 LPs performed by 7 neurologists. The neurologist performing the LP recorded type and size of needle, intensity of pain, safety, time of the procedure and failure or success. Between 5 and 15 days later another neurologist, blind for the type of needle used, completed an ad-hoc questionnaire for PDPH.

Results: PDPH developed in 35.9% patients when using a 20Q needle, in 12.9%, 6.8% and 1.6% respectively when using a 22S, 25W or 25S needle. The difference in incidence of PDPH following LP performed with 20Q needle and 25S or 22S was statistically significant ($p<0.001$ and $p=0.008$ respectively) and it approached significance when comparing 25S and 25W ($p=0.06$). As 25W and 25S needles need CSF aspiration LP requires more time and skill. Pain caused by LP was similar with the 4 needles.

Conclusion: The use of 25S needle in diagnostic LP reduces the frequency and severity of PDPH.

Introduction

Post-dural puncture headache (PDPH), formerly called post-lumbar puncture headache,[1] is a very common complication of lumbar puncture (LP) and it is caused by a persistent leak of cerebrospinal fluid (CSF) from the dural puncture site. LP is performed for diagnostic purpose by neurologists and for the injection of anesthetics by anesthesiologists. Different types of needles can be used. They differ for diameter, measured in Gauge (G), for the shape of the tip and for the necessity or not of an introducer. The “traumatic” Quincke (Q) needle has a sharp, bevel end which cuts the dural fibres whereas the “atraumatic” Whitacre (W) and Sprotte (S) needles have a pencil or an ogival tip respectively, which outspread the fibres causing minor traumatism.[2] As atraumatic needles cannot cut the skin, muscles and ligamentum flavum they require an introducer. With 24G or smaller diameter needles aspiration of CSF is needed because of the very slow flow especially if the patient is lying on his/ her side.

The American Academy of Neurology (AAN) discussed PDPH twice and released ad-hoc guidelines on the prevention of post-lumbar puncture headache (PLPHA) in the attempt to modify the traditional way of neurologists to perform diagnostic LP. The AAN guidelines in 2000[3] and its addendum in 2005[4] recommend the use of a 22G atraumatic needle instead of the traditional 20G Quincke in diagnostic LP to reduce PDPH. The AAN also highlighted that “smaller needle size is associated

with reduced frequency of PLPHA". In spite of the AAN recommendations the use of 22G atraumatic needle has not become standard practice in the neurologic community [5,6]. Even though atraumatic 22G needles cause less PDPH than cutting needles, PDPH remains a very common complication of LP ranging from 24.4% to 12.2%.[7, 8, 9]

The risk of PDPH is substantially reduced by the use of smaller, 24G-26G, non-cutting needles, a long-standing standard procedure among anaesthesiologists [10]. Although anesthesiologists must inject anesthetics and neurologists must aspirate CSF the same small type of needles could be used as suggested by 3 neurological studies using 24-26G needles: a randomized double-blind clinical trial in normal individuals[11] and two studies in Alzheimer and control subjects[12, 13]. The percentage of PDPH in those studies was 12%, 4%, and 0.93 % respectively.

Neurologists are reluctant to change the traditional way of performing LP and to adopt atraumatic needles with an introducer in routine clinical practice and the most common reasons given are: higher cost, greater difficulty, slow flow of CSF requiring aspiration with negative pressure, longer time of the procedure and concerns about patients' safety[14].

The main goal of the present study was to verify if changing the traditional way of neurologists to perform LP can avoid unnecessary morbidity of the patients undergoing LP. For the first time 25G needles, requiring an introducer and CSF aspiration, were used for LP during routine neurological clinical practice. This study tested 4 needles different in diameter and shape of the tip in a rater-blind prospective study in 394 LPs performed by 7 neurologists.

Patient population and study design

The study was approved by the ethics committee of San Luigi Hospital, Orbassano, Italy and all patients signed an informed written consent.

Three-hundred-ninety-four LPs were performed in 376 patients during routine clinical practice by 7 neurologists at Centro Riferimento Regionale Sclerosi Multipla (CRESM) in Piedmont. **According to the usual clinical practice, before undergoing LP the patients were informed about the risks associated with LP, including PDPH, and about how LP is performed. The patients were blind about the type of needle used, their characteristics and the need of an introducer and of CSF aspiration with 25G needles. Before performing the LP, the patients were asked if and how much pain they expected to feel.**

LPs were performed in the morning with the patient sitting or lying on his/ her side and the stylet was reinserted before needle withdrawal. **The opening pressure was not measured because it was not necessary for the diagnosis of the patients enrolled in this study, but it can be evaluated with all the types of needle used [11].** Patients were asked to remain recumbent for 2h following LP.

Exclusion criteria were platelet count < $80x10^9$/L, suspected increased intracranial pressure, and a previous LP in the

previous week.

In 282 patients (75.1%) the suspected diagnosis prompting LP was either MS or Clinical Isolated Syndrome (CIS). The other 94 patients belonged to one of the following subsets[15]: non-inflammatory neurologic disease (n = 47; 13.3%), inflammatory neurologic disease (n = 25; 7.2%); peripheral inflammatory neurologic disease (N = 11; 3.2%); and symptomatic “controls” (n = 4; 1.2%).

The neurologist performing LP filled in the structured data-collection form which included the following information: diagnostic suspicion, patient's position, vertebral space, number of attempts and failures, time spent for LP and CSF collection, mls of CSF drawn, expected and experienced pain assessed by the Eleven Point Box Scale (BS11)[16]. A neurologist, blind for the type of needle, interviewed the patients for PDPH 5 -15 days after the LP. PDPH was defined according to the International Headache Society (http://ihs-classification.org)[1]. Its severity was graded *according to Lybecker and collaborators [17] in* ***none, mild, moderate and severe PDPH. In details, mild PDPH is a postural headache that slightly restricts daily activity; the patient is not bedridden at any time during the day and there are no associated vestibular, cochlear, ocular, or musculoskeletal symptoms. The moderate PDPH is a postural headache that significantly restricts daily activities. The patient is bedridden part of the day; associated symptoms may or may not be present. The severe PDPH is a postural headache that results in desire of the patient to stay in bed all day. Associated symptoms are***

always present. In the questionnaire, PDPH severity was graded as none (value = 0), mild (value 1-2), moderate (value 3-4) or severe (value 5-6). PDPH duration and the medications used were also recorded. The number of Red Blood Cells (RBC) in the CSF was counted in the first of the tubes.

The study included 2 phases: in the first phase a 25W needle (Artsana, Grandate, Italy) was introduced into the clinical practice for comparison with the traditional 20Q needle and the 2 needles were used alternatively; after an interim analysis showing the definitely lower frequency of PDPH with 25W, only this latter was used. In the second phase Sprotte needles, both 25S and 22S (Pajunk, Geisingen, Germany) in the ratio 2:1 were used. In case of failure 20Q needle was used. A minority of LPs**, 11 cases, was performed with 22Q, due to unavailability of 25G needles and it was not considered for comparison with the other groups. All the LPs were performed by 7 neurologists in the same in-patient unit, the Centro Riferimento Regionale Sclerosi Multipla at San Luigi University Hospital, Orbassano (Italy). The type of needle was established a priori by one of the neurologists (AB), to avoid a choice based on the patients' risk profile for PDPH or on the neurologist's experience in performing LP.** The stylet was reinserted after CSF collection [18] and the Quincke needles were placed with the bevel oriented in a parallel/longitudinal direction in order to decrease the incidence of PDPH[19].

Statistics

Continuous data are expressed as median, with an interquartile range as a measure of variability. Chi-square and Fisher test were used for qualitative analysis; Mann-Whitney test was used for quantitative analysis with Hochberg adjustment for multiple comparisons. Risk factors for development of PDPH were evaluated by a logistic regression model and a univariate estimate of the Odds Ratios (ORs) was presented along with their 95% Confidence Interval (95%CI). The level of significance was considered as $p<0.05$. Analyses were carried out using R version 3.02.

Results

A total of 394 LPs were included in the study: 376 LPs were performed successfully using one of the 5 types of needles as follows: 39 with 20Q, 11 with 22Q, 62 with 22S, 133 with 25W, 131 with 25S needle. In 18 LPs 2 types of needles were used, because of failure with the first type. In 18.2% of the patients tapped with 22Q PDPH occurred, but the subset included only 11 patients and it was not considered for further analysis.

All groups of patients (20Q, 22S, 25W and 25S) showed similar median age (43, 44, 40, 40), ranging from 17 to 84 years (table 1).

Women accounted for the majority of patients ranging from 74.4% in the 20Q group to 69.2% in the 25S group without any statistical significance (table 1).

The body mass index (BMI) spanned from 15 to 45, without statistical difference among the four groups (table 1).

In the great majority of LPs (70.3% to 96.2%) the patient was lying; the highest number of patients sitting (29.7%) was observed with.

Failure

We considered a failure when despite several attempts the neurologist was not able to perform the LP with the selected type of needle and he had to use a bigger needle. The 18 failures were so distributed in the groups: 2 out of 41 (5%) with 20Q, 2 out of 64 (3%) with 22S, 9 out of 142 (6%) with 25W, and 5 out 136 (4%) with 25S. In the 16 failures occurred with small needles LP carried out with a bigger needle was successful. No statistical difference was observed among the 4 groups; however, a learning curve seems to be present as the percentage of failure was 3.5% (7 out of 200 LPs) in the second part of the study (22S and 25S needles), versus 6.0% (11 out of 183 LPs) in the first part of the study (20Q and 25W needles). PDPH was reported in 2 out of 16 failures. These cases were not taken into account for the evaluation of PDPH prevalence as two different types of needle were used.

Time spent for needle insertion and CSF collection

Unlike cutting needles 20Q or 22Q, small needles 25W and 25S and the atraumatic 22S require the introducer, which takes 1-2 minutes to be inserted. The time spent for the collection of CSF ranged from 1 min to 40 min depending on the amount of CSF collected, the position of the patient, the diameter of the needle, the possible aspiration of CSF and the neurologist's

skill. The median time spent with 20Q was 3 min, shorter than with 22S (5 min), 25W (15 min) and 25S (7 min) (table 1). The longer time for LP with 25W and 25S needles is due to the need for CSF aspiration, performed with a 5 ml syringe connected to the needle when this has reached the subarachnoid space. The manoeuvre allows the collection of 3-5 ml of CSF at a time and it must be repeated to obtain the volume needed for diagnosis and bio-banking. The volume of CSF collected ranged from 3 to 20 ml, with median values 9, 15, 10 and 13 for 20Q, 22S, 25W and 25S respectively. The amount of CSF was larger with Sprotte needles, both 22S and 25S (table 1).

Traumatic LP

Traumatic LP, that is the presence of red blood cells (RBC) in the CSF, was evaluated using the Nageotte chamber and counting the number of RBC in the first tube of CSF. The percentage of CSF with a number of RBCs lower than 5/µL ranged from 61.5% to 73.6%, being higher with the small needles, without statistical differences (table 1). As RBCs lower than 500/µL is the threshold used for proteomic studies[20], the percentage of LPs suitable for those studies ranged from 92.3% to 97.7%, higher in the 25G needles subgroup but without statistical significance.

Pain expected and experienced during LP

The median expected pain was similar in the four groups, ranging from 7 to 8 in the Eleven Point Box Scale (BS11) and the median experienced pain was definitively lower, ranging from 3 to 4 ($p < 0.0001$ for all needles). The experienced pain was

similar with the 4 needles, unaffected by the introducer and by CSF aspiration.

PDPH: incidence, severity, days of recovery

PDPH was observed in a total of 33 patients out of 376 (8.8%) so distributed: 14 out of 39 (35.9%) with 20G, 8 out of 62 (12.9%) with 22S, 9 out of 133 (6.8%) with 25W and 2 out of 131 (1.6%) with 25S. The risk of PDPH with 20Q was statistically higher than with all the other needles tested (table 1); the incidence of PDPH was significantly lower when using 25S than 20Q and 22S ($p<0.001$ and $p=0.008$ respectively) and lower but without statistical significance with 25W ($p=0.06$). **The analysis of the 33 cases of PDPH in the present study showed that the advantage of small needles is also clearly evident when we consider the duration of PDPH and the severity of the pain experienced by the patients. The median intensity** of PDPH was lower with both 25G needles, as none of the 11 cases of PDPH was considered severe, whereas 12.5% of 22S-linked PDPH and 18.2% of 20Q-linked PDPH were severe. The median duration of PDPH was longer with 20Q and 22S than with 25W, being 4, 4.5 and 2 days respectively; in the 2 cases tapped with 25S PDPH lasted less than 24h in one case and one week in the second. Re-admission to the hospital and brain CT scan were necessary in one patient with severe headache after LP performed with 20G needle.

PDPH was not correlated with volume of CSF collected, patient's age, sex, BMI, position during CSF collection, suspected diagnosis, and previous LP (table 2). No significant interaction among the risk factors listed above was observed in

multivariate logistic analysis.

Discussion

PDPH, a very common complication of LP, is due to intracranial hypotension caused by CSF leaking through the meningeal opening left by the needle[6]. The pain can be severe and it may last for several days. Rare complications of CSF hypotension are cerebral sinus thrombosis, subdural haematoma **and deep venous thrombosis caused by possible bed confinement for several days**[6, 21]. The diameter of the needle is the main factor influencing PDPH [3, 4]; the AAN guidelines in 2000[3] and in 2005[4] stated the superiority of 22S atraumatic needle versus 22Q or 20Q needles in decreasing the risk of PDPH. However also using 22S needle the frequency of PDPH is still a very common complication as it occurs in 12.2% of LPs according to Strupp et al[8], in 12.9% in the present study, and in 19% and in 24.4% in two other studies[7, 9]. The goals of the present study were to explore safety and feasibility of needles smaller than 22G, namely 25G, during diagnostic LP in routine neurological practice and to compare the risk of PDPH of 4 different types of needles. This approach is consistent with the AAN guidelines [3,4] stating that “smaller needle size is associated with reduced frequency of PDPH”, it is supported by extensive anesthesiologic literature [10, 22] and by 2 research studies in Alzheimer and control subjects [12, 13] performed with 25W[12] and 24S needles [13] and reporting 4% and 0.93% of PDPH respectively. The use of small needles during diagnostic LP contrasts with the traditional neurological practice and encounters the reluctance of neurologists

grounded on a long list of concerns: higher cost, greater difficulty, slow flow of CSF requiring aspiration with negative pressure, longer time of the procedure and lower patients' safety.[14]

The present study showed that the use of atraumatic 25S needle with CSF aspiration for diagnostic LP reduces the risk of PDPH up to tenfold. In fact 22S needle caused PDPH in 12.9% patients, versus only 1.9% of patients with 25S. Once more this study confirms that the diameter of the needle is crucial for the appearance of PDPH: both 25G atraumatic needles, namely 25W with pencil point shaped tip and 25S with an ogival tip, were associated with lower occurrence of PDPH than 20Q and 22S (Tab 1).

The comparison between the two 25G needles used in our study indicated that 25S is less frequently associated with PDPH than 25W (6.8% versus 1.6%; p= 0.06) and it suggests that also the shape of the tip can play a role in the occurrence of PDPH. This is consistent with 2 other studies comparing needles with the same diameter but different shape of the tip and showing that the atraumatic 22S needle was associated with lower PDPH than 22Q (12.2% versus 24.4%; 19% versus 32%, respectively)[8, 9]. At the best of our knowledge, the lowest reported percentages of PDPH in diagnostic LP are 0.93%[13] and 1.6% of the present study both obtained with small, 24 or 25G, Sprotte ogival-tip needles.

The cases of PDPH in the present study showed that small needles were associated with shorter duration and lower intensity than larger needles as none of the 264 cases of PDPH after LP performed with small needles was classified

as severe, and none required re-admission to the hospital for severe and persistent headache. Many factors have been suggested to cause PDPH.[6] In the present study we avoided two of them, by reinserting the stylet [18] and by positioning the Quincke needle parallel to the long axis of the spinal cord [19]. Volume of CSF collected, sitting or lying position, previous LP, BMI, age and gender were not associated with a higher risk of PDPH, in agreement with several studies[6, 23]. **It must be noted that the present study has a limited capacity to detect risk factors as it included only 33 cases with PDPH and the 95% confidence intervals are wide (Table 2).**

This study indicates that 25G needles require more time than traditional ones as they need an introducer to pierce the skin, muscles and ligamentum flavum and they require CSF aspiration. Besides the neurologist must have greater skill, that can be acquired and improved through experience. In the first part of our study, which compared 20Q with 25W, the median time spent with 25W was 15 min, whereas in the second part of the study which compared 22S and 25S, the median time with 25S was 7 min (25W vs 25S $p<0.001$), because the 7 neurologists performing LPs became more confident with small needles. The higher skill needed to perform LP with 25G is also highlighted by the 14 LPs successfully performed with 20Q after failure with 25G.The longer time spent with 25G is easily counterbalanced by less time spent in the management of less frequent and severe PDPH [5].

Safety is one of the neurologists' concerns in using 25G needles because aspiration of CSF is required. **Aspiration of CSF**

through a syringe during LP seems to be a dangerous procedure that increases the risk of brain herniation, however the data collected in this study and in previous ones [12, 13] do not support this fear: no patient had discomfort and none required re-admission to the hospital for persisting headache. **Brain herniation depends on high intracranial pressure, mainly due to brain tumors, and on the speed of CSF efflux. A CT scan before LP excluded the presence of brain tumor in this study. The speed of CSF efflux with 25S, evaluated in ml/min, was similar to that with 20Q and less than with 22S (Tab. 1). The neurologist can control the speed of CSF efflux through small needles by changing the degree of aspiration. This is not possible with bigger needles and the efflux depends only on the intracranial pressure.**

The risk of damage to nerve root filaments caused by aspiration through the tip of the needle was also ruled out, as the pain referred by patients was similar with all the needles (Tab. 1). Pain during LP was evaluated asking the patient to indicate the expected pain before the procedure and the actual experienced pain. The data demonstrated how inconsistent the popular belief that LP causes “unbearable” pain: the median expected pain was more than 7, in a scale ranging from 0 to 10, and the experienced median pain was between 3 and 4; with all the needles the experienced pain was statistically lower than the expected pain ($p < 0.0001$). The belief of the neurologists that the use of an introducer increases the patient’s pain is not confirmed by our data, but it must be noted that the diameter of the introducer for 25G needle is 21G, smaller than the

traditional needles.

The present study was not set up to evaluate the cost of the procedure, but other studies have already shown that the use of a needle reducing the risk of PDPH is cost-effective[24, 25]. In our centre 25G needles cost 4€ more than 20G needles and they require more time from nurses and neurologists performing the LP. However these higher costs are easily rewarded by the lower occurrence of PDPH, which is expensive and time-consuming. In fact the severity and duration of PDPH was lower with 25G than with 22S and 20Q; 1 out of 39 20G-patients with PDPH had to undergo a brain CT-scan during re-admission to the hospital at a cost of 500€ a day, while none of the 264 25G-patients was readmitted.

Although the volume of CSF collected for diagnosis is generally lower than 5 ml, a volume of at least 12 ml is recommended for diagnostic and prognostic tests and for bio-banking.[20] Our data show that it is possible to collect up to 20ml of CSF with every type of needle without increasing the risk of PDPH and the discomfort for the patient.

To test if the introducer increases the percentage of "traumatic" LPs contaminated by blood, the number of RBCs in the first tube of CSF was counted: the data showed that the percentage of LPs containing more than 5 or more than 500 RBC/µL was similar in the four groups of patients and not influenced by the introducer (table 1). This finding is not surprising as the introducer does not enter the subarachnoid space and the smaller the needle the lower the chance to injure capillaries or venules and to cause leaking of RBCs into CSF.

In our study we did not use blood patches in patients with severe PDPH lasting more than one week. Although the procedure has some adverse effects [27], blood patches have been shown to reduce severity and duration of PDPH [1, 26] and we will them take into consideration in future studies.

We hope our work can convince neurologists that PDPH is, in a great number of cases, an avoidable side effect. Neurologists should implement the use of 25S needle in everyday clinical practice by trying a small needle first, and in case of failure, the traditional larger needles. As anesthesiologists currently use small needles with an introducer, a short training in an anesthesiology department could help.

In conclusion this study comparing four types of needles confirmed that PDPH is influenced by diameter and shape of the needle tip and indicated that 25S needle is associated with very low frequency of PDPH. Diagnostic LP with 25S needle is safe and it can be performed in routine clinical practice but it requires higher skill than traditional LP. Neurologists can avoid 9 out of 10 PDPHs if they change their traditional way of performing LP.

Bullet points

- ✓ We test the feasibility of lumbar puncture using 25 gauge (G) needles in everyday clinical practice and quantified the risk of PDPH of 4 different types of needles in 394 lumbar puncture performed by 7 neurologists.
- ✓ We confirmed that PDPH is influenced by diameter and shape of the needle tip and demonstrated that 25 Sprotte needle is associated with very low frequency of PDPH (1.9%)
- ✓ 25 Sprotte needle reduces the risk of PDPH almost ten times in comparison with 22 Sprotte needle.
- ✓ We hope our work can convince neurologists that PDPH is, in a great number of cases, an avoidable side effect.

- ✓ Neurologists should implement the use of 25S needle in everyday clinical practice by trying a small needle first, and in case of failure, the traditional larger needles.

Competing interests: Antonio Bertolotto, Maria Malentacchi, Marco Capobianco, Alessia di Sapio, Simona Malucchi, Annalisa Pulizzi, Yana Motuzova, Paola Berchialla and Francesca Sperli certify that all conflicts of interest, including specific financial interests and relationships and affiliations relevant to the subject matter or materials discussed in the manuscript (eg, employment/affiliation, grants or funding, consultancies, honoraria, stock ownership or options, expert testimony, royalties, or patents filed, received, or pending), are the following: None

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Table 1 Patients and lumbar puncture characteristics by needle type

	20Q	**22S**	**25W**	**25S**	
	N=39	N=62	N=133	N=131	
Age	43 (30-52)	44 (34-52.5)	40 (32-50)	40 (30.5-48)	NS
	[18-84]	[21-72]	[18-79]	[17-73]	
Gender					NS
female	74.4%	72.6%	69%	69.2%	
Male	25.6%	27.4%	31%	30.8%	
BMI	24.1 (21.5-28.3)	23 (20.6-24.8)	22.5 (20.3-25)	22.1 (20.2-24.3)	NS
	[15-37.02]	[18.07-45.35]	[18-35.16]	[18.03-32.56]	
Position					
sitting	29.7%	11.3%	3.8%	3.8%	20Q vs 25W ($p<0.001$); 20Q vs 25S ($p=0.006$)
lying	70.3%	88.7%	96.2%	96.2%	

Number of failure	5% (2)	3% (2)	6% (9)	4% (5)	NS
Minutes for CSF collection	3 (1-10) [1-20]	5 (4.25-6) [1-20]	15 (10-18) [2-40]	7 (5-10) [1-15]	25W vs 20Q (p=0.002); 25W vs 22S and 25W vs25S (p<0.001); 22S vs 25S (p=0.018)
Velocity of CSF efflux, ml/min	2.7 (0.85-5.5) [0.4-10]	3 (1.7-3) [0.4-7.5]	0.8 (0.6-1) [0.3-5.5]	2 (1.3-2.7) [0.1-6]	25W vs 20Q (p=0.013); 25W vs 22S and 25W vs 25S (p<0.001); 22S vs 25S (p=0.023)
CSF collected, ml	9 (8-10) [5-15]	15 (12-15) [5-15]	10 (10-12) [3-20]	13 (12-15) [6-20]	P < 0.001 for all pairwise comparison

RBC/µL	0-4	61.5%	62.3%	67.7%	73.6%	NS
	≥5	38.5%	37.7%	32.3%	26.4%	
RBC/ µL,	0-500	92.3%	95.1%	96.2%	97.7%	NS
	≥500	7.7%	4.9%	3.8%	2.3%	
Pain Expected		7 (5-8) [1-10]	8 (6-10) [1-10]	7 (5-8) [1-10]	8 (5-10) [1-10]	NS
Pain Experienced		3 (1-5) [0-10]	4 (2-5) [0-10]	3 (1-4) [0-10]	3 (2-5) [0-10]	NS
PDPH Frequency						
	Yes	35.9%	12.9%	6.8%	1.6%	20Q vs 25W (p<0.001); 20Q vs 25S (p<0.001); 20Q vs 22S (p=0.036); 22S vs 25S (p=0.008)
	No	64.1%	87.1%	93.2%	98.4%	

PDPH severity	3 (2.5-4) [1-5]	3 (2-3.25) [1-6]	1 (1-3) [1-3]	2 (1.5-2.5) [1-3]	NS*
PDPH class severity					
mild	27.3%	37.5%	60%	50%	
moderate	54.5%	50%	40%	50%	
severe	18.2%	12.5%			
PDPH duration, days	4 (3-6) [0-10]	4.5 (2-5.5) [1-6]	2 (1-5) [0-8]	4.5 (2.25-6.75) [0-7]	25 vs 20S (p=0.08)*

Value are expressed as median, in brackets the interquartile range and in square brackets the range. BMI – body mass index; NS - not significant; CSF – cerebrospinal fluid; RBC – red blood cells; PDPH – post-dural puncture headache; * only two patients had PDPD with 25S needles and statistical evaluation is not possible.

Table 2. Risk factors for development of post-dural puncture headache

Risk factor	Presence of PDPH N=33	Absence of PDPH N=332	OR	95% CI	p-value
Gender					
female	69.7%	70.2%	Ref		
male	30.3%	29.8%	1.02	(0.47; 2.23)	0.95
Age	40 (29-50)	41 (32-50)	0.84	(0.49; 1.45)	0.53
BMI	23.3 (22.1-24.0)	22.5 (20.2-25)	1.28	(0.8; 2.02)	0.3
Position					
sitting	15.6%	8.2%	2.07	(0.73; 5.89)	0.17
lying	84.4%	91.8%	Ref		

Diagnostic suspect					
CIS and MS	86.7%	74.4%	2.24	(0.76; 6.62)	0.14
other	13.3%	25.6%	Ref		
Previous LP					
yes	16%	19.4%	0.79	(0.26; 2.4)	0.68
no	84%	80.6%	Ref		
CSF collected, ml	10 (8-14)	12 (10-15)	0.63	(0.35; 1.13)	0.12

For age, BMI and ml of CSF collected, ORs are calculated on an interquartile difference of 19 years, 4.6 point of BMI and 5 ml respectively. PDPH – post-dural puncture headache; BMI – body mass index; CIS – clinically isolated syndrome; MS – multiple sclerosis; LP – lumbar puncture; CSF – cerebrospinal fluid